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APPROACH TO REGIONAL MICROELECTRONICS CO-OPERATION PROGRAMME**

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I. Observations on Brazilian Electronic Industry

In 1983, the Brazilian electronic equipment production reached $ 3.7 billion, which originated a demand of $ 190 million in the semiconductor sector.

In order to supply this internal demand, 17 semiconductor manufacturers have produced $ 130 million, of which $ 28 million for exports. This required the importation of $ 26 million of inputs. Additionally, imported finished semiconductors amounted to $ 90 million.

Recently, equipment design has been strongly affected by the increasing trend of IC technology to integrate more and more functions in a single chip. As a result, equipment design is progressively merging with chip design.

As the Brazilian electronic industry does not master the highly complex know-how in the semiconductor sector (from design to marketing), its trend has been to become more dependent, mainly due to the increasing use of custom-made ICs in modern systems.

In 1983, the ten largest world-wide semiconductor manufacturers have reached sales of $ 9.5 billion, i.e. 55 percent of the world market. Four of them have sold more than $ 1 billion. Only Texas and Motorola have produced more than $ 3 billion, this is 16 times bigger than the Brazilian market.

The Brazilian industry has faced great difficulties in trying to implement the complete semiconductor production cycle. Among these difficulties, we have:

- the lack of industrial scale for mass-production equipment;
- the large diversity in semiconductors types and quantities, partially due to the different origins of equipment designs locally manufactured;
- the lack of up-to-date technology;
- the limited skilled human resources.

The semiconductor industry is capital intensive and even a small industrial unit requires high investment. Marketing practices of the big

multinational manufacturers - consisting in producing in huge volumes for the world market and in introducing a constant flow of new products at very low prices - make it difficult for a local manufacturer of standard products to achieve the industrial scale required for the feasibility of a local complete production cycle.

Today, the microelectronic field presents one of the quickest technological evolutions. High investments may become obsolete in a short period, without being paid off. In many cases, companies not able to follow this evolution have been absorbed by others, in order to avoid more dramatic solutions.

Although Brazil has several nuclei of specialists in R and D centres and industry, they are in a limited number and work with insufficient financial resources. So, it has been impossible for us to cope with the high technology internationally available and therefore our production does not reach the world market competitively.

However, the world-wide trend of using more customized ICs for big production series of equipment and semicustomized ICs being economically feasible for smaller series, opens a new perspective enabling the industries from developing countries to design and produce microelectronic components for their needs. So, we can develop a high technology activity and a complete production cycle, enabling our local microelectronic industry to become internationally competitive in many market segments.

But the development of these devices will require high technological capabilities in design methodologies and in computer-aided design tools.

A regional co-operation programme will enable developing countries to develop, in the productive area:

- new methodologies and production processes;
- inputs development and manufacturing;
- acquisition, improvement, design and production of machinery and tools;
- training of skilled human resources.

Regional co-operation can also be a manner of increasing the number and the results of the research centres' developments, as well as local developments through an R and D programme organized on a regional level, avoiding redundant efforts. It should also be stressed that the exchange among researchers and technicians will speed up the work at these centres.

Countries which have similar technological levels can implement an effective co-operative programme in human resources development. This will certainly be the quickest and most economical way to enhance their skills in this high technology field, leading to a socio-economic development less dependent on developed countries. A regional co-operation programme should also establish the joint operation of inputs and finished semiconductors industries, in order to reduce the production costs.

II. Approach to a Regional Microelectronics Co-operation Programme

A. Industry

(1) Projects concerning microelectronic elements

Centralization of the production processes and the decentralization of design is the industrial trend in modern microelectronics. Microcircuit quality results as much from the production equipment as from design tools, and both should be constantly optimized and updated. Therefore within three years Brazil will need five times more qualified human resources specialized in hardware, software, documentation and communication systems. It constitutes a necessary condition to improve the efficiency of existing project groups in Brazil.

In the field of microelectronics regional co-operation could be most useful in promoting development of an integrated system project in the countries of the region.

. This co-operation would be aimed at forming a critical mass of microelectronic semi-custom and full-custom projects. It includes specifications, measuring and testing for integrated circuits.

. A critical mass of developers of CAD tools for testing of gate-arrays, integrated circuits, standard cells and full-custom digital and analogue circuits.

. Integrated circuit projects that may be disseminated to an increasing number of users at competitive prices.

. Research programmes for improving CAD tools for integrated circuits.

. Execution of production processes in the region, together with the implementation of locally developed processes.

. Creation of a regional project station with a complete ICs cells library interconnected through communication means (DATA TX) to the various domestic low-cost project stations in order to process a substantial part of the programmes necessary to each project.

This goal could be attained through the following activities:

- Software and hardware standardization to allow for the communication and portability of programmes being used.

- Project and design methods established pursuant to domestic and/or foreign procedures.

- Software professional documentation and libraries necessary to the project.

- The search for persons who have already proposed, created, prepared, characterized and evaluated new structures or materials.

- Availability of courses.

(2) Final Product

Domestic companies, as SID MICROELECTRONICA, HELIO DINAMICA, AEGIS AND ITAU COMPONENTES can be interested in creating a technological co-operation programme and a products and inputs industrial completion programme for their production, i.e.:

- production equipment (diffusion and assembly)
- production processes
- quality control (reception, production processes and tests)
- personnel training
- MASKS manufacture and supply
- Chips diffusion and supply
- final product supply (to complete the marketing supply line)

(3) Inputs

(a) Electronic grade silicon

The R+D centres and the Brazilian industry are able to co-operate with industries abroad by supplying technology and training human resources in the fields of:

- Metallurgic grade silicon
- Trichlorosilane
- Polycrystalline silicon
- Monocrystalline silicon
- Cut and/or polished wafers (for solar cells production)

(b) Silicon wafers

The Brazilian industry needs highly resistant wafers obtained from monocrystalline silicon produced by float zone method for I.C. diffusion. Two million dollars are deemed necessary for producing 300 000 wafers with 75-100 mm diameter.

(c) Photomasks

Photomasks are scarcely used in Brazil. The small quantity used is economically not viable. It should be considered, however, as a strategic need for implementing the semiconductor projects developed locally.

Taking into account the production scope of Brazilian and Latin American industries, one single photomasks generation centre would meet the needs of local industry to LSI ICs level. A plant like that could copy working photomasks. With the existing designs made by the R&D laboratories of industries it could also prepare photomasks.

Other systems could be installed at a later stage in semiconductor devices industries.

- High grade purity metal
- Thin wires and wires for evaporation

Gold and aluminium ultra-thin wires are used to some extent in Brazil. In 1982, the assembly and manufacture industries used three million metres of golden wire (diameter 25, 50 and 75 micron) and three hundred thousand metres aluminium wire (25 micron). 80 micron golden wire is manufactured by a Brazilian industry and will soon be entering the market.

Since refining and shaping of microwires is already performed in Brazil, the industrial scale to be reached through regional co-operation (the implementation of a manufacturing system - 500 000 dollar investment) for that purpose seems feasible.

(d) Frames and cases

The high aggregate value for the final product costs and relatively low investment as well as global market opportunity make the manufacture of lead frames and cases the most economic product for the microelectronic industry.

In order to increase industrial scale of production and reduce costs, the number of different lead frames geometry should be reduced and metal alloys production should encouraged.

Three companies are operating in Brazil aiming at that purpose. Experts have estimated that 250 000 dollars would be necessary for development of metal alloys and plates.

Brazilian industry can supply progressive stamp tools for the manufacture of lead frames.

(e) Chemistry products

The electronic chemistry industry has not been developed enough for high grade production and has no R&D capabilities.

Initially, it would be necessary to refine at electronic level the organic acids and solvent. Those are mostly used in local industry. At a later phase photoresistants, dopants, gases and other products are to be produced.

(f) Epoxies and silicons

These products have great economic significance and need highly sophisticated technology. The Brazilian chemical industries do not reach electronic grade quality in these products:

- Metallized clay capsule
- Desoxide super cover and bases for semiconductors
- Quartz tube for diffusion

These inputs are not manufactured in Brazil.

Other industrial programmes could be implemented in the form of regional co-operation:

- Industrial production technique programme on microelectronics: aimed at exchanging and creating new industrial production techniques, moving the industry and R&D efforts for developing basic techniques for the implementation of new products and methods.

- Checking and quality guarantee techniques development programme: aimed at disclosing quality guarantee techniques for microelectronic methods and products.

- Microelectronic equipment and tools programme: aimed at improving and developing new equipment and tools for microelectronics. Industries, R&D agencies and universities should be encouraged to participate in this programme.

- Microelectronic metrology programme: manufacturing projects and methods characterization is a basic factor for microelectronic quality and product control.

B. Research and development

(1) R&D at the university

The main hindrance consists of the significant limitation of qualified personnel. A great effort should be made towards training human resources at the university. The exchange with foreign institutions is a basic factor to speed up their education on the appropriate level. Research should stress education rather than production. Research problems should be updated in order to enable the students to perform and/or follow up the most advanced world developments.

(2) R&D institutes

International and regional co-operation is a basic factor for achieving good results in a given area. Investments in the most advanced technological research activities should not be granted for the purchase of sophisticated equipment. It should be a result of a natural evolution of research activities. Group activities should be encouraged, especially on MOS Bipolar 12 L, thin and thick films, quantic optics, epitaxial growing, ion implantation technology, and on research in raw material and development of new methods for electrical measures.

Particular attention should be devoted to research for the industrial consolidation of technology using 1,5-2μm geometry for mid-term microstructures and 1μm for long-term ones, as well as the creation of project capability programmes as well as the manufacture and characterization of power devices.

(3) R&D in industry

Industries should perform R&D work related to all products intended to be manufactured on an industrial basis.

The R&D effort should concentrate, then, on the technology used by industry itself.

The semiconductor companies should perform R&D work especially on:

- Devices projects
- New project techniques
- New production techniques
- Quality control and default analysis methods
- New assembly systems and methods
- Testing and test methods criteria

A regional co-operation programme with the purpose of assisting the implementation of R&D in companies would be most desirable.

C. Human resources

In 1982 Brazil had 335 microelectronic specialists; 42 on graduate level. This number is extremely low if compared with the 8 000 microelectronics experts of BELL LABORATORIES (USA).

The remaining 293 experts concentrate their activities on packing and test phases. A few have some experience on circuits diffusion and conception phases. At industrial level, circuit diffusion and conception is practically unknown in Brazil, except by a small group working at SID SEMICONDUCTORS.

The requirements for the next five years comprise 35 method experts and 100 project experts at the R&D centres as well as 240 experts for the universities.

Other supporting activities (industrial engineering, maintenance, quality control etc.) will also require technical qualification. Industry would require 50 experts graduated on methods and 200 experts graduated on projects. Our present capacity to train human resources at this level is inadequate.

The lack of human resources, investments and limited time turn this programme into a task that can be accomplished only with extensive regional and international co-operation.

Visiting professors should be invited to give courses at the existing centres and a post-graduate programme abroad should be implemented.

Regional co-operation for obtaining human resources could be made at the following levels:

- Technical
- Graduate
- Post-graduate

Technical and graduate levels would have two basic purposes: the education of experts for production and selection of new researchers who would be further educated .

Subjects should relate to special topics as materials engineering, microelectronics, solid state physics, chemistry, metallurgy etc.

Post graduate education should result in high qualifications as researchers, professors and technicians to work in the various sectors of microelectronics.

In view of the lack of human resources and in order to obtain higher efficiency, specialization of educational centres existing in several countries of the region would be advisable.